

# 2004 DOE Program Review Presentation

## Hydrogen Generation from Electrolysis

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**TELEDYNE**  
ENERGY SYSTEMS, INC.  
A Teledyne Technologies Company

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# Objectives

- ▶ To advance water electrolysis technology and develop an Electrolytic Hydrogen Generator with the following features:
  - ◆ Delivers hydrogen at high-pressure, 5,000 psig
    - Develop a relatively inexpensive hydrogen generation & pressurization solution
      - Collaborate with compressor manufacturer
      - Collaborate with power supply manufacturer
  - ◆ Production capacity 10,000 scfd
  - ◆ High conversion efficiency
  - ◆ Cost objective < \$600/kW for 10,000 units per year
  - ◆ Reliable, low maintenance cost, & durable





# Budget

- ▶ Total funding for the project = \$3,127,764
  - ◆ DOE share = \$1,563,882
  - ◆ TESI share = \$1,563,882
- ▶ Total funding in FY04 = \$490,000
  - ◆ DOE share = \$245,000
  - ◆ TESI share = \$245,000

Power  
Systems

Gas  
Systems



# Technical Targets & Barriers – Efficiency

## Based on 2005 Targets & LHV of H<sub>2</sub>

<u>Characteristic</u>	<u>Target</u>	<u>Barrier</u>
Power Conversion	Efficiency = 96%	AC to DC: Turndown ratio & rectification technology DC to DC: Matching power source with the H <sub>2</sub> Generator
Cell Stack	Efficiency = 70%	Membrane resistance, catalyst technology, corrosion due to hi-temp operation
Balance of Plant	Efficiency = 97%	Gas purification technology & other parasitic losses
Compression	Efficiency = 90%	High-pressure gas generation and motor & compression technology

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# Technical Targets & Barriers – Cost

<b><u>Based on 2005 Targets &amp; LHV of H<sub>2</sub></u></b>		
<b><u>Characteristic</u></b>	<b><u>Target</u></b>	<b><u>Barrier</u></b>
Power Conversion	Cost = \$0.21/kg	Mfg & Rectification technologies
Cell Stack	Cost = \$0.79/kg	Mfg & Production technology
Balance of Plant	Cost = \$0.14/kg	Gas purification & mfg technology
Compression	Cost = \$0.21/kg	Compression & mfg technology

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# Approach

- Develop low-cost, high efficiency, & safe alkaline water electrolysis system for hydrogen production
  - ◆ Small-scale membrane testing & development for high-pressure and high-efficiency
  - ◆ Conceptual system optimization
    - Pressure vs. hardware cost trade studies (As the system and compressor pressures increase, the cost of components increases.)
  - ◆ Optimize cell, stack, & system designs
    - Catalysts
    - Parasitic loss reduction
    - Power supply & compressor optimization
    - Design for manufacturing & assembly



# Project Safety

- ▶ TESI has over 30 years of commercial hydrogen generation and safety related experience.
  - ◆ Users are trained to safely operate the systems.
  - ◆ Generators are typically monitored for cross-contamination and out-of-tolerance conditions.
  - ◆ Generator installation areas are constantly monitored for hydrogen concentrations and sometimes infrared emissions.
- ▶ HAZOP & FMEA studies will be performed as part of the trade studies and on final system.

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# Project Timeline

03/04 - 09/04			10/04 - 9/05		9/05 - 9/06			10/06 - 02/07	
<b>Phase I</b>			<b>Phase II</b>		<b>Phase III</b>			<b>Phase IV</b>	
1	2	3	4	5	6	7	8	9	

## Phase I – Feasibility

1. High-pressure membrane testing
2. High-pressure cell design & testing
3. Component trade studies

## Phase II – System Conceptualization

4. System conceptual design & trade studies
5. Stack modeling & design





# Project Timeline (cont'd)

03/04 - 09/04			10/04 - 9/05		9/05 - 9/06			10/06 - 02/07	
Phase I			Phase II		Phase III			Phase IV	
1	2	3	4	5	6	7	8	9	

## Phase III – Finalize design & Implementation

6. Complete system design & component selection

7. DFMA studies

8. Build demo unit

## Phase IV – Site Test

9. Factory test & deliver demo unit to site, begin site testing, performance verification, public awareness & education



# Interactions & Collaborations

- ▶ AeroVironment Inc.: Charles Botsford – Maximizing safety, reliability, power conversion efficiency, and reducing cost.
- ▶ Pdc Machines, Inc.: Sy Afzal - Maximizing safety, reliability, & compression efficiency, and reducing cost.
- ▶ Maryland Energy Admin.: W. Dale Baxter - Cooperation for providing a demonstration site and public education & awareness.





# Future Work

## PRODUCT PORTFOLIO

- ▶ Perform according to the timeline



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